Space Weather Technical Forecast

Issued on Sunday, 19 March 2023 at 01:16 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor Storm intervals with CME glance possible day 2 or 3 (20th or 21st) but low confidence. Chance of M-flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with an impulsive C9.4 flare observed at 18/0716 UTC from AR3256 on the southeast limb. There are currently three numbered sunspot regions on the visible disc. AR3256 is the most complex in the southeast disc, with more complexity becoming apparent as it rotates into view. This is a wide group, consisting of a large leader and smaller trailer spot with some ongoing flux emergence around both these spots. Newly numbered AR3257, which is south of AR3256 is also moving into view, with a preliminary assessment, but this will likely evolve as it continues to rotate into view. AR3251 in the southwest is a small and simple spot, as is the new and currently unnumbered region, which has emerged in the northeast.

A large filament eruption which occurred on the 17th March produced a CME, which has been analysed and results suggest a possible glancing blow at Earth either on late on Day 2 or early Day 3 (20-21 Mar), although most of the material is expected to miss to the south and ahead of Earth. Smaller filaments were also observed lifting from the northwest disc during the 17th March, however, no CMEs have been observed. Geomagnetic activity is low confidence due to these eruptions.

No other Earth-directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured at L1, was slightly elevated at around 400-470 km/s throughout, with density near or below average. The total IMF strength Bt, was weak, around 6nT, with the north-south component Bz ranging between +/-5nT. The phi angle was predominately positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 2-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES-16 is slightly above background, but now below 1pfu and continuing a slow decline after the enhancement on 13 March. The high energy electron flux (greater than 2MeV) has been at background with the associated 24-hour Electron fluence below Active (1e8 integrated pfu). At 19/0000 UTC the observed fluence was 2.95e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low activity is most likely, but with a chance of increasing to Moderate at times with isolated M-flares throughout. These most likely from AR3256 or AR3257 in the southeast, or from other regions rotating onto the southeast disc, and also onto the northeast disc later in the period.

Solar Wind / Geomagnetic Activity: A glancing CME impact is possible day 2 or early day 3

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

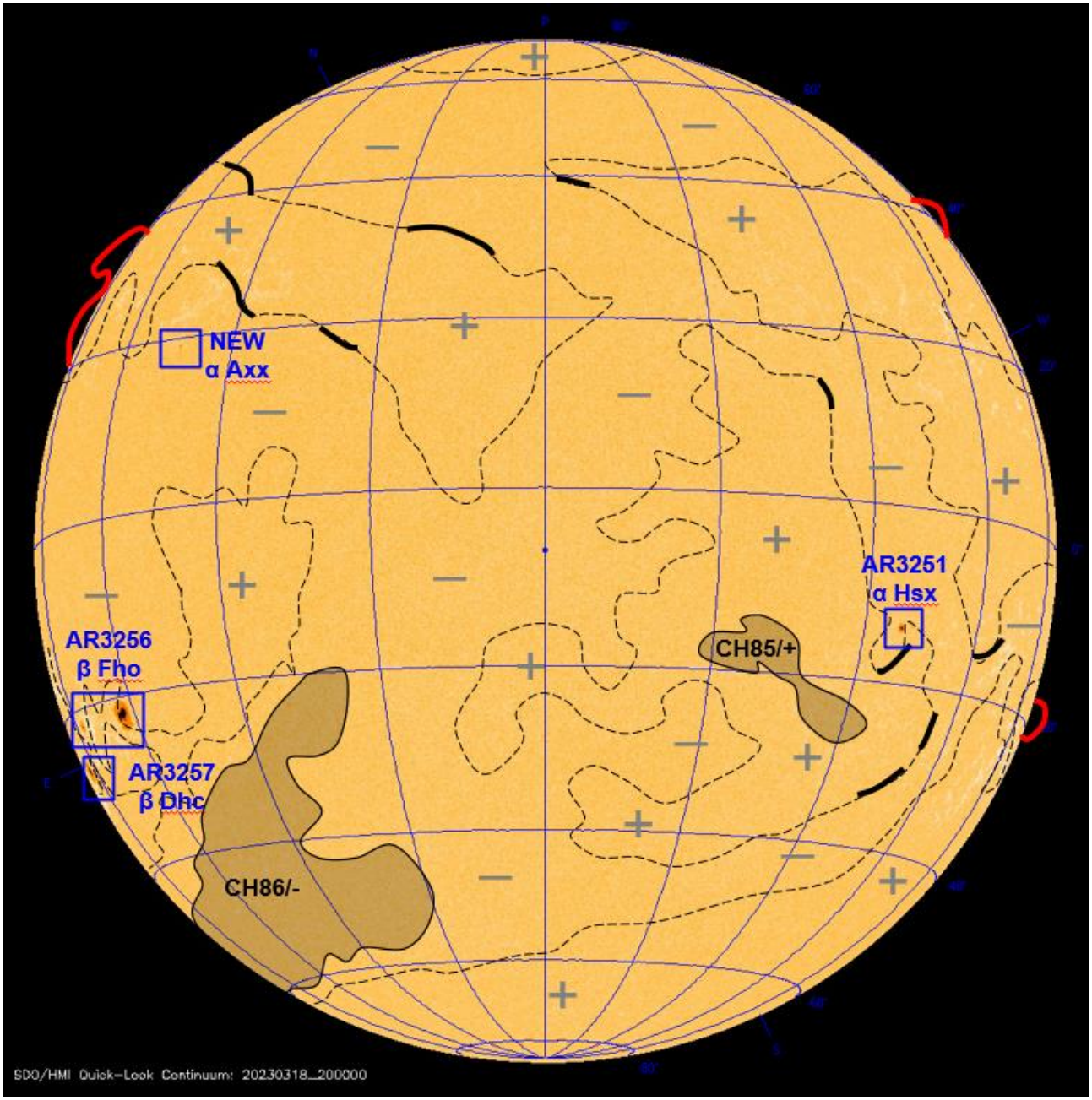
(20th or 21st), however this is low confidence. This will come alongside a muted connection to the fast wind from CH84/+. Geomagnetic activity is expected to be mainly Quiet until this HSS arrival, then becoming Unsettled with Active intervals likely. Any CME arrival will likely increase this further, to Active to G1 Minor Storm intervals. Activity then likely easing later day 3 and day 4 (21-22 Mar). However, the large coronal hole (CH85/-) currently located in the southeast is likely to bring the next HSS either late on day 4 (22 Mar) or just beyond the forecast period, which will further increase geomagnetic activity.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to continue easing to background, with no further significant enhancements currently anticipated. The high energy electron flux is expected to persist at background, perhaps rising a little Day 3 (21st) as a result of the connection to CH84/+ and any CME arrivals. Confidence is low for any notable increase however, with the associated 24 hour fluence expected to remain below the Active threshold.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1. Solar Analysis Valid 18/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

The CME from 17th March has been assessed as passing mostly ahead and south of Earth, but with a glancing impact likely late on day 2 or early day 3 (20th or 21st). This is a low confidence forecast as coronagraph imagery is currently limited.

There is one small coronal hole feature expected to influence conditions at Earth during the next four days, CH84/+. The fast wind associated with this feature has the potential to bring some increased geomagnetic activity day 2 (20th) as Earth moves into its HSS. In the absence of any CME arrival this would likely be rather muted due to the Russel-McPherron effect resulting in positive features connecting less strongly near the March Equinox, perhaps peaking at Active with only a very slight chance of G1/Minor Storms. However, alongside the low confidence CME, there is a chance of activity increasing to G1/Minor storm later day 2 (20th).

The next large coronal hole (CH85/-) currently located in the southeast will bring the next HSS probably late on day 4 (22nd) or just beyond this forecast period. CH85 is further back compared to previous rotation, but appears to be stronger in appearance.

Mainly Quiet geomagnetic activity is forecast day 1 (19th), increasing to Unsettled with Active intervals with any fast wind transition into day 2 (20th), easing day 3 (21st). This perhaps increasing to Active to G1 Minor storms with any CME arrival. Activity then likely easing later day 3 (21st). Mostly Quiet on day 4 (22nd), although possible arrival of the next HSS from CH85/- may increase geomagnetic activity later in the day, or just beyond the forecast period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	30	20	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

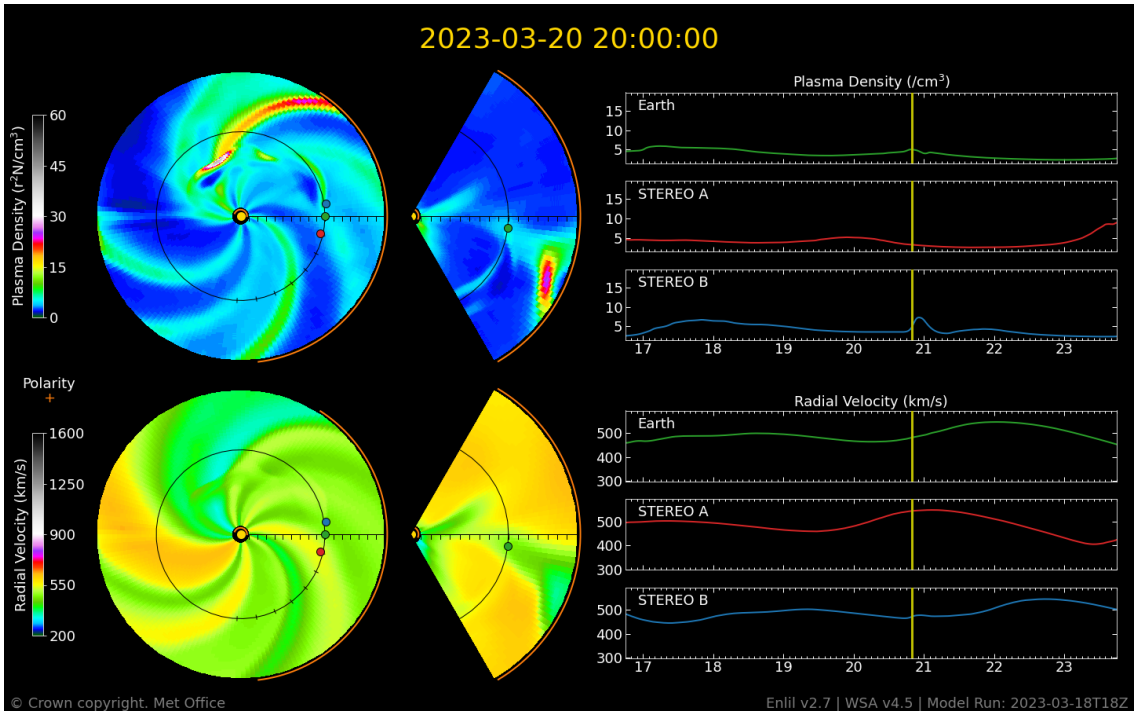
Geomagnetic Activity - Earthbound Coronal Mass Ejections

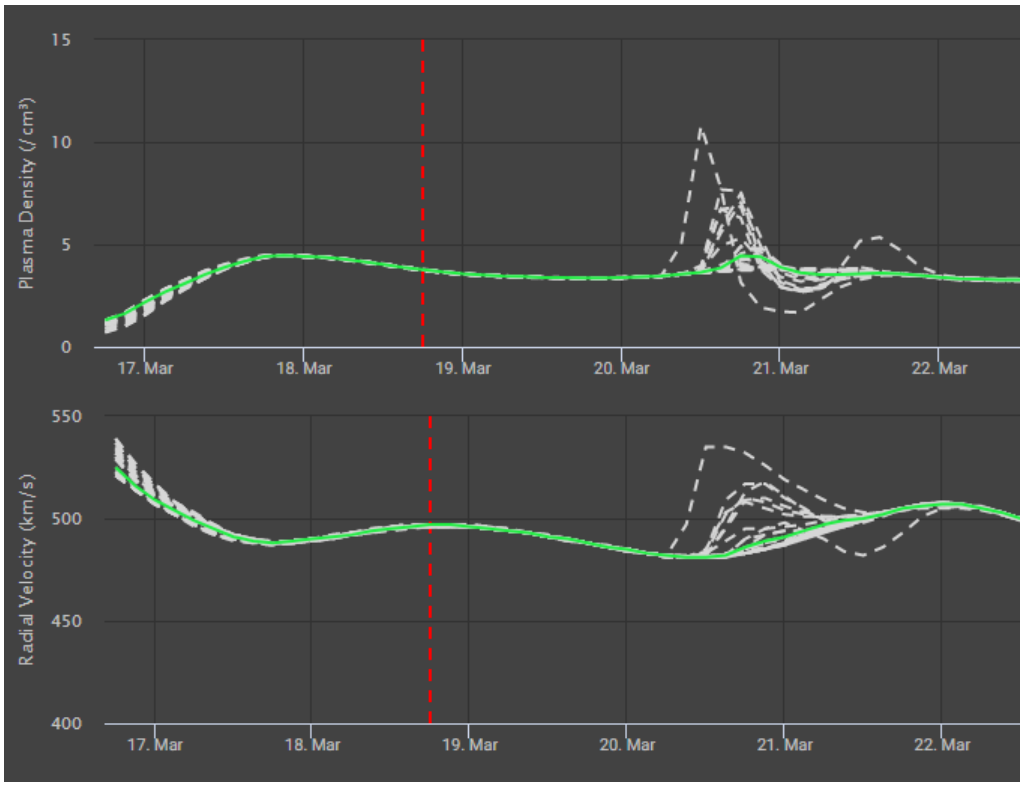
Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
17/1610 UTC	Partial	Filament	SW	510km/s	20/2100 UTC +/- 9 hrs	Low confidence glancing blow, with most material missing

Figure 2: ENLIL and Ensemble, shows the CME passing south and ahead of Earth, with a low confidence glancing blow possible either on the 20th or 21st March.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.





Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

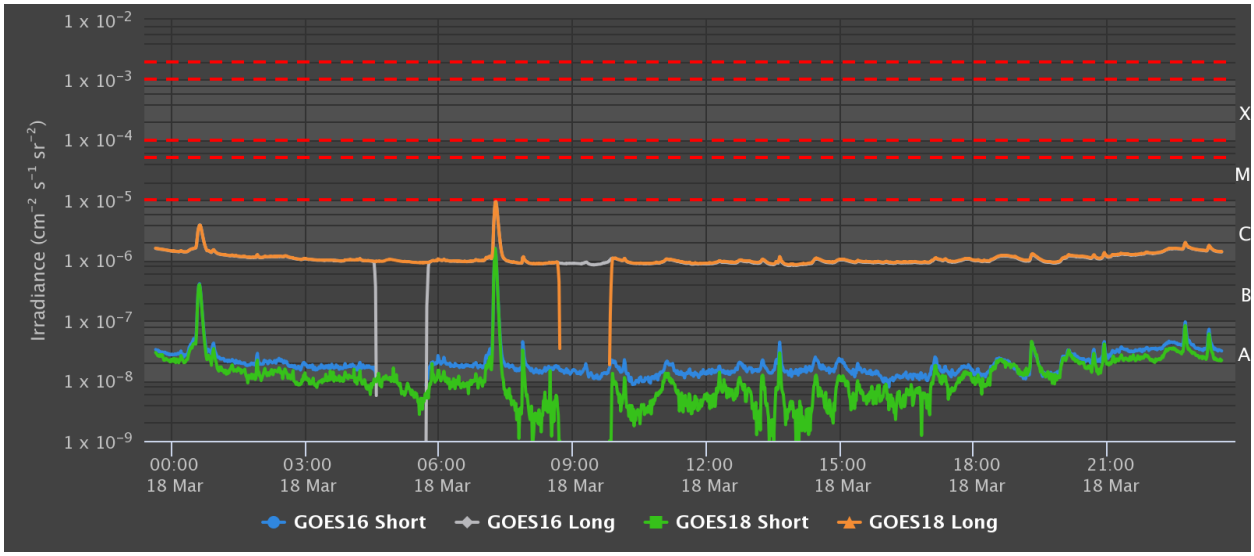
© Crown Copyright 2023. All Rights Reserved.

Radio Blackouts - X-Ray Flares:
Solar activity is expected to be mainly Low, with a chance of rising to Moderate. There is also a very slight chance of this rising to High. AR3256 Fho/Beta is currently the most notable numbered region on the disc, comprised of a large leader with some flux emergence around it and a smaller trailer, also with smaller spots. As this moves into a less oblique viewing angle more complexity is gradually becoming apparent, although it may yet be more appropriate to split this into two smaller separate sunspot regions. The other numbered regions are smaller and simpler.

A newly numbered region AR3257 has emerged to the south of AR3256. Despite being on the limb, a strong trailer spot is already identifiable, with a potential leader, along with an east-west aligned polarity separation line. Coupled with the bright flux visible on STEREO-A euvi and significant magnetic looping on e.g. SDO aia-171, these all point to an increased flare potential. Significant looping is also evident over the horizon in the northeast disc. This is potentially due to the region that was responsible for the large far-side CME on 13 March, which may be returning ex-AR3234. This also ties in with a strong helioseismic signal across the Suns northern hemisphere, which may also include ex-AR3243 which is expected to return towards the end of this period. Overall, this brings a slight chance of strong flares, although this forecast will be refined further as these regions become more visible.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES X-Ray flares



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 4: SDO HMI-Intensitygram and magnetogram of AR3256 and AR3257 in the southeast. A possible new region emerging from around the limb.

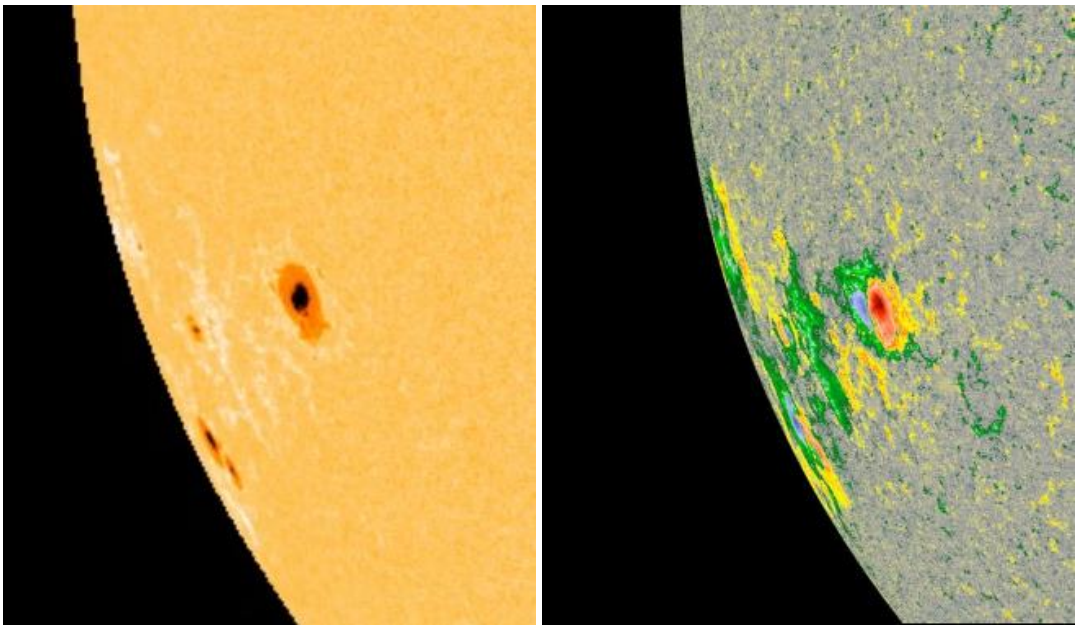
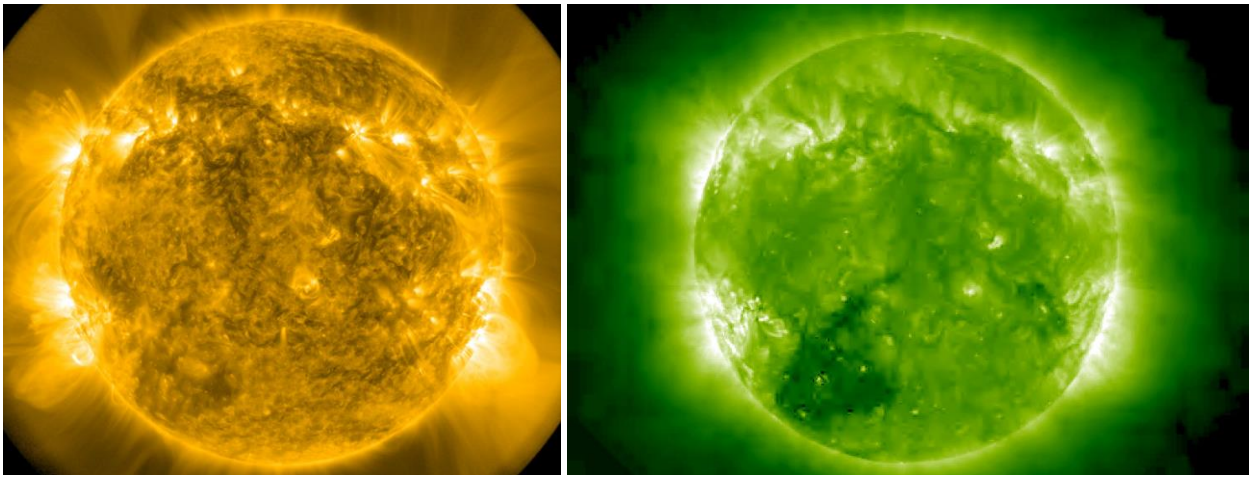


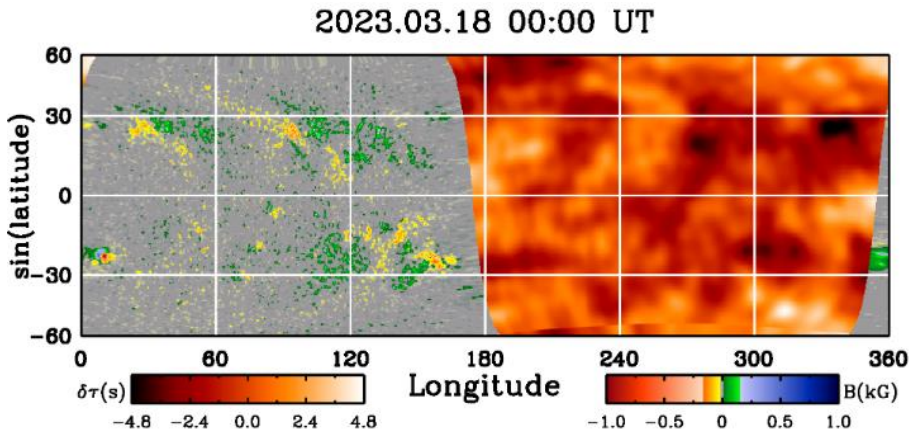
Figure 4a: SDO aia-171 (left) and STEREO-A (right) show significant magnetic looping on the east limb.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 4c: Time-Distance Helioseismic far-side imagery (jsoc.stanford.edu) shows potential 'dark patches' highlighting ARs which are due to rotate onto the visible disc in the coming days.

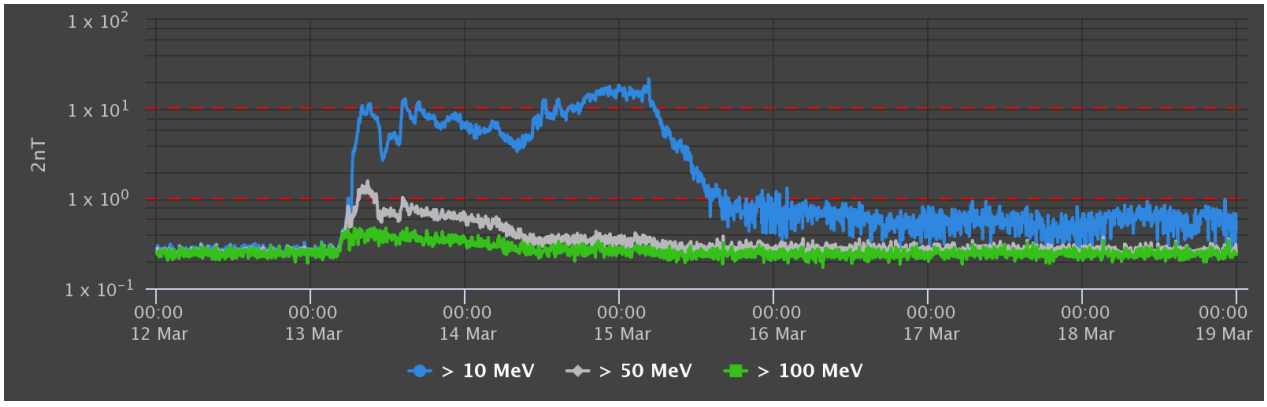


Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES-16 is currently very slightly above background as it continues to gradually decline from the S1 Minor Radiation storm event earlier this week. No further notable proton enhancements are currently anticipated, with the most notable sunspot regions in a less favoured region for connection to Earth should any significant flares occur.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: GOES-16 >10MeV, >50MeV and >100MeV proton flux over the last 7 days



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

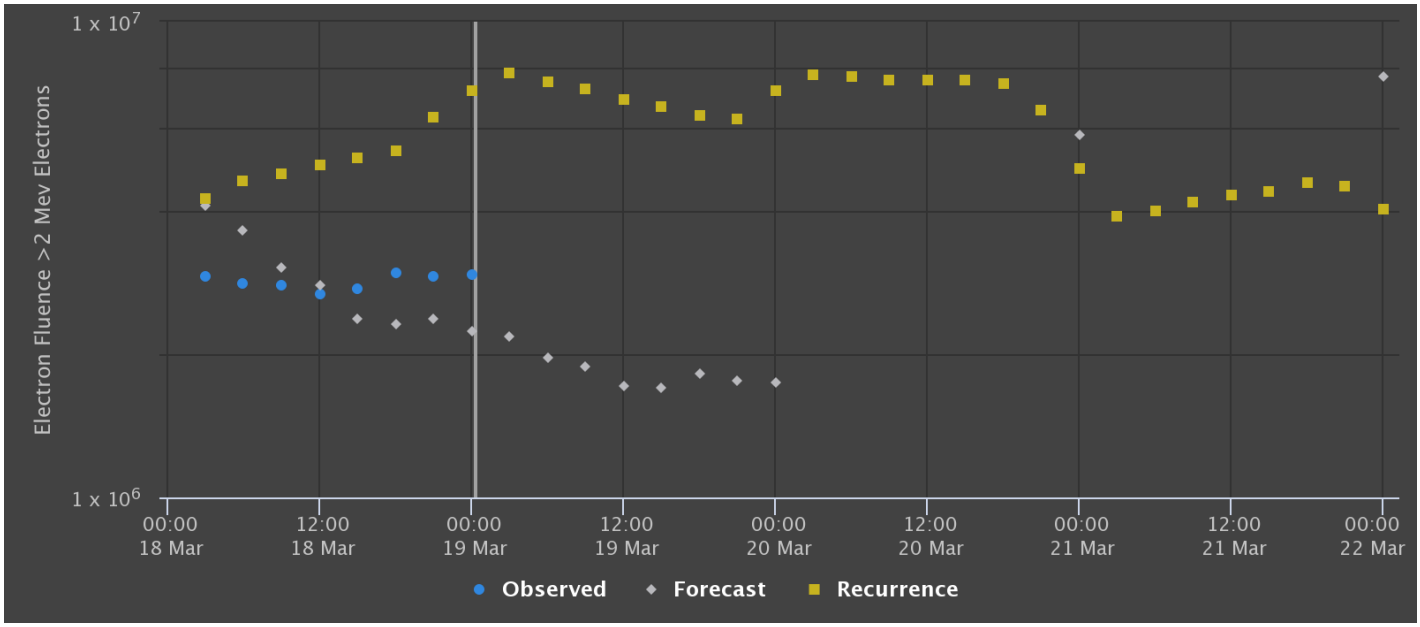
© Crown Copyright 2023. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):
The high energy (>2MeV) electron flux observed by GOES-16 is currently mainly at background, with no significant enhancements now expected until at least day 2 (20th) with the transition into the fast wind of CH84. This enhancement is also expected to be muted, and alongside the potential for a CME glance on day 2 or early day 3 (20th and 21st), confidence remains low for any notable increase in flux levels beyond this date.

The associated 24 hour fluence is expected to be below the Active (1e8 integrate pfu) level with REFM currently giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 6: REFM electron fluence.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.